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OCCURRENCE AND DISTRIBUTION OF ALIEN INVASIVE TREE SPECIES IN THE ITALIAN FORESTS

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Abstract

The spread of alien plants, intentionally or accidentally introduced by human activity into areas outside their native ranges, is one of the threats to natural ecosystems. Particularly the alien plant species defined as "invasive" may alter ecosystem processes and threaten the survival of native species in natural ecosystems or cause a critical economic impact in agriculture. The paper presents some data about the occurrence and the distribution of alien invasive tree species in the Italian forests derived from the Italian national forest inventory.

Key words: alien invasive species, biodiversity, forest inventory.

Introduction

The uncontrolled spread of alien species, defined as "plant species whose presence in an area is due to intentional or accidental introduction by man" (Richardson et al. 2000), represents an important cause of the loss of biodiversity at the global level.

With reference to their current invasion status, Richardson et al. (2000) divide the alien species into three categories: casual alien plants, naturalized non-invasive plants and invasive plants.

This paper focuses on the third category, the invasive alien species, defined as "naturalized plants that produce reproductive offspring, often in very large numbers, at considerable distances from parent plants, and thus have the potential to spread over a considerable area" (Richardson et al. 2000).

At the European level, several inventories of invasive alien species have been compiled. The international project DAISIE (Delivering Alien Invasive Species Inventories for Europe 2008), funded by the VI Framework Programme of the European Commission, has provided a global inventory of alien plant species in the pan-European region.

Due to its specific climatic conditions, Italy is one of the European countries most affected by the invasion of alien species. Its territory has been a centre of intense exchange and colonization of non-native biota as a result of human trade and migrations ever since ancient times (Blasi et al. 2007).

The project "A survey of the non-native flora of Italy", funded by the Italian Ministry for the Environment in the years 2005–2008, produced a database on non-native plant species in Italy. This inventory listed 1,023 alien species, of which 154 invasive.

The aim of this paper is to present some data on the occurrence and the distribution of alien invasive tree species in Italy derived from the analysis of the national forest inventory data. As a first step, the list of alien species published by Celesti-Grapow et al. (2009) within the above mentioned project was compared with the list of tree and shrub species recorded during the inventory surveys. The collected data were processed to estimate the number of stems, the basal area and the volume per hectare of invasive alien species and to give some information on their distribution in the Italian forest stands.

Material and Methods

The second Italian National Forest Inventory (National Inventory of Forests and forest Carbon pools – INFC) is an important source of data for forestry and natural ecosystems management. It provides reliable and updated information, consistent with international standards, about the forest resources at national and regional level, including forest biodiversity.

The INFC adopted a three-phase sampling design for stratification (Gasparini et al. 2010), with three samples of approximately 300,000, 30,000 and 7,000 samplig units. The first sample was used to assess the land cover/land use by photo-interpretation of digital orthophotos (first inventory phase). The classification system adopted is consistent with the first level of the CORINE Land Cover System (European Commission 1993) and with the FAO (2001) – Forest Resources Assessment (FRA 2000) definition of Forest and Other Wooded Land (OWL) (UN-ECE/FAO 1997). The quantitative measurements (counts of stems by species, diameter, tree height, etc.) were taken in the field during the third phase. The field plots were randomly selected from the second phase sample and stratified by administrative district (21 regions) and forest type (23 types). The forest type was classified in the field on the basis of the prevailing tree species in the sample plot (INFC 2003). Figure 1 shows the inventory plot design. The measurements were

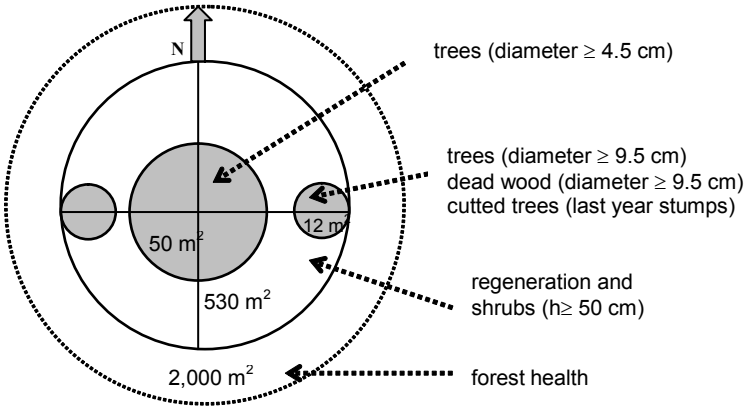

Fig. 1. National Forest Inventory ground plot configuration.

taken in different sized plots: two circular concentric plots for dendrometric measurements (50 m^2 and 630 m^2), two small satellite plots for forest regeneration and shrubs (12 m^2), a larger plot (2000 m^2) for the forest health survey and qualitative measurements (INFC 2006, Gasparini et al. 2010). Trees with a diameter at breast height (DBH) larger than 4.5 cm and 9.5 cm were measured respectively within the two concentric plots for dendrometric measurements; forest regeneration and shrubs include all stems with a DBH smaller than 4.5 cm and a height larger than 50 cm.

The total and per hectare estimates of the observed or derived variables (number of stems, basal area, growing stock, etc.) were obtained using the estimators proposed by Fattorini et al. (2006).

For this study, the field data concerning invasive alien species were processed separately to estimate the number of stems, the basal area and the stem volume (total and per hectare values) of these species at national and regional level and by forest type. Moreover, data on regeneration of invasive alien species were used to estimate the number of regeneration stems, for comparison with the same estimates on non-invasive alien species. The alien species classification adopted is the one proposed by Celesti-Grapow et al. (2009).

Results and Discussion

Comparing the list of Celesti-Grapow et al. (2009) with the list of the species recorded during the INFC field surveys, a noteworthy feature is that 34 alien species were found, of which 15 naturalized, 10 casual and 9 invasive. Table 1 gives the list of the invasive alien species surveyed by INFC.

In 440 of the 6,685 plots surveyed during the inventory, one or more stems of invasive alien species (DBH $\geq$ 4.5 cm) were counted (Fig. 2). Within "forest" category of INFC, the total number of alien species stems represented 4.43% of overall total and 2.7% was the proportion of invasive alien species. In terms of basal area and volume, the proportion of invasive alien species was 1.9% and 1.8%, respectively. Focusing on "tall trees forests", the most important inventory category (8,582,968 ha on 8,759,200 ha of the total forest area), table 2 gives the total and per hectare estimates of the number of stems, basal area and volume for invasive alien

Table 1. List of invasive alien species recorded during the Italian National Forest Inventory surveys.

Species	Common name	Habitus
Acacia dealbata Link	silver wattle	shrub
Acer negundo L.	ash leaved maple	tree
Ailanthus altissima (Mill.) Swingle	tree of heaven	tree
Amorpha fruticosa L.	false indigo	shrub
Opuntia ficus-indica (L.) Mill.	prickly-pear cacti	shrub
Prunus laurocerasus L.	laurel cherry	shrub
Prunus serotina Ehrh.	wild black cherry	tree
Quercus rubra L.	red oak	tree
Robinia pseudacacia L.	black locust	tree

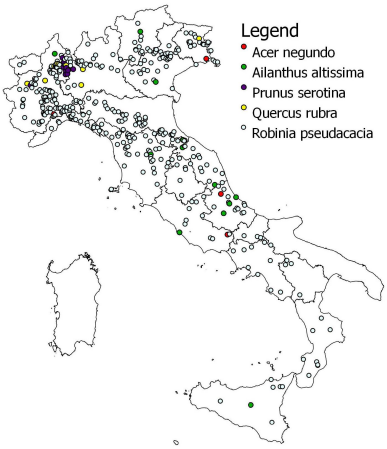

Fig. 2. Map of National Forest Inventory plots with invasive alien tree species.

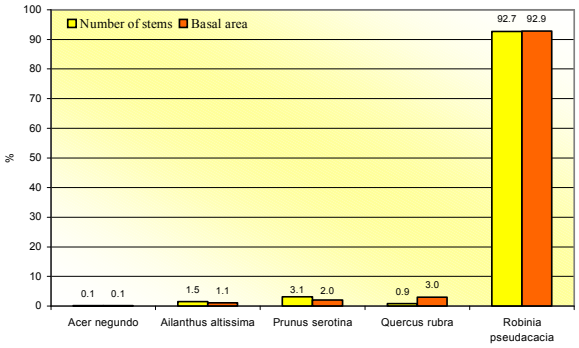

Fig. 3. Proportion of invasive alien tree species in terms of number of stems and basal area ("tall trees forest" category).

tree species, compared with the same estimates for other species. Figures 3 and 4 show the proportion of invasive alien tree species respectively by species and forest type. The forest type with the highest value of alien species was the "other deciduous broadleaved forests"; one fourth of this forest type (233,553 ha, 2.7% of tall trees forests) was represented by invasive alien tree species dominated mainly by black locust stands. Coniferous forest types and cork oak stands were almost not affected by invasive alien species.

Figures 5 and 6 show the total volume and the number of stems of inva-

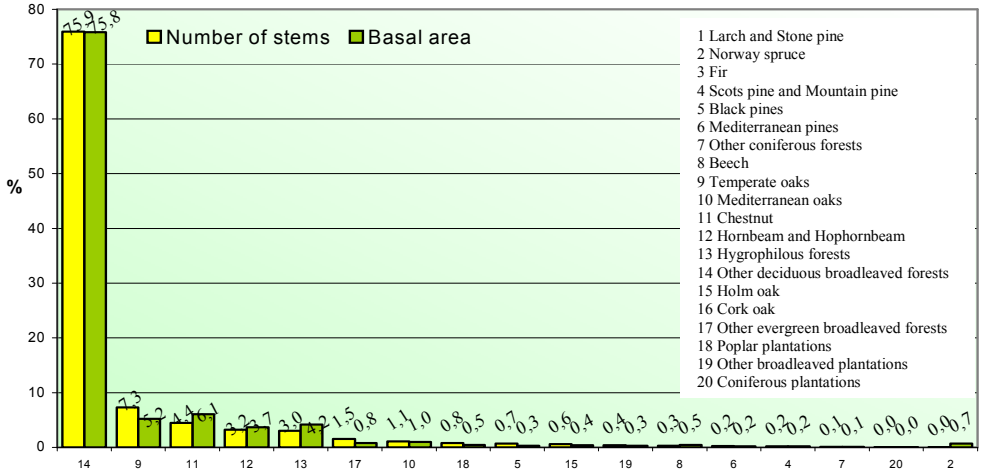

Fig. 4. Proportion of invasive alien tree species in terms of number of stems and basal area by forest type.

Table 2. Total and per hectare estimates at national level of dendrometric parameters ("tall trees forests" category).

Species	Number of stems		Basal area		Volume	
	n	$n.ha^{-1}$	m^2	$m^2.ha^{-1}$	m^3	$m^3.ha^{-1}$
Invasive alien species	314,520,116	36.6	3,343,897	0.4	22,618,478	2.6
Other species	11,556,715,954	1,346.5	173,380,117	20.2	1,233,481,015	143.7

sive alien species in the Italian administrative regions.

As shown in figure 3, the most widespread species, within "tall trees forest" category, is *Robinia pseudacacia* L., (more than 92.7% of the invasive alien species stems counted by INFC, 92.9% of the total invasive alien species basal area). *Prunus serotina* Ehrh., *Ailanthus altissima* (Mill.) Swingle, *Quercus rubra* L. and *Acer negundo* L. are the other main invasive alien species.

The highest values for the number of invasive alien stems were found in Piemonte, Lombardia, Toscana and Emilia Romagna. These results are consistent with those obtained by Celesti-Grapow et al. (2010).

Finally, figure 7 shows the percentage of invasive alien species regeneration and its distribution by species. Invasive alien species were found in 220 of the 4,850 plots with regeneration. The total and per hectare number of invasive alien species regeneration stems compared with the same statistics for other species are given in table 3.

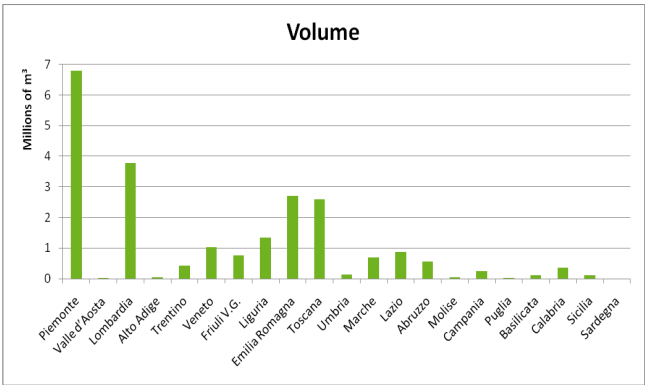

Fig. 5. Total growing stock of invasive alien species by regions.

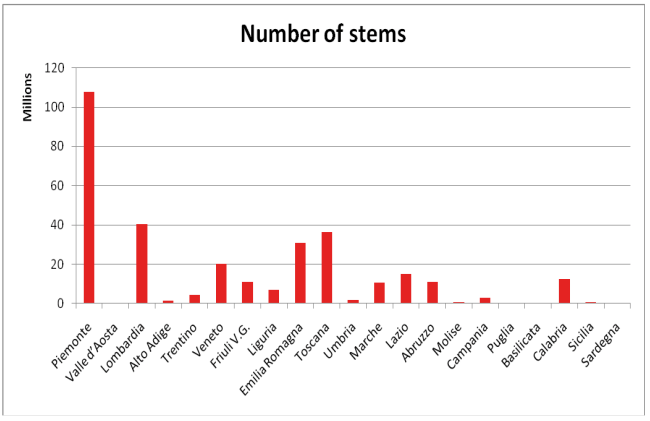

Fig. 6. Total number of stems of invasive alien species by regions.

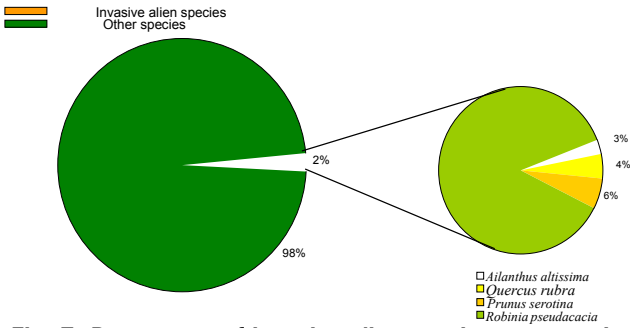

Fig. 7. Percentage of invasive alien species regeneration and its distribution by species.

The main statistics concerning invasive tree species produced by the national forest inventory give a general picture of the occurrence and distribution on these species in Italy. The percentage standard error of estimates is generally high (80% or more) as a consequence of relatively low sampling intensity, that is suitable for the purposes of the forest inventory and not specifically for a invasive alien species inventory.

The data presented in this paper seem to suggest a limited occurrence of these species, both in the overstorey and in the regeneration storey. The data obtained by Celesti-Grapow et al. (2010) confirm that the number and density of non-native species is highest in artificial land use types.

Closed-canopy forests have long been cited as highly resistant to invasion. However, while invasion of forests (in particular by shade-tolerant exotics) may be a slower process than the establishment of exotic species in disturbed or open ecosystems, the long-term effects are likely to be just as pervasive (Martin et al. 2009).

The level of knowledge on the alien flora in Italy varies considerably within regions. In order to identify management priorities and gain a better understanding of plant invasion processes, it is crucial to distinguish, among the high number of plants that make up non-native floras, those species that pose a major threat to the environment or other aspects of human life owing to their high rate of spread and current or potential impact. One essential, basic step in this direction consists of gathering information on the distribution and invasion status of each species, on the differences in the land use in which they occur (e.g. man-made or natural) and on the type of impact they cause (e.g. ecological or socioeconomic) (Celesti-Grapow et al. 2010).

The forest inventory data give a general picture of invasive alien species occurrence and distribution in Italy. Further analysis could

Table 3. Total and per hectare number of regeneration stems ("tall trees forests" category).

Species	Number of stems	
	n	n.ha^{-1}
Ailanthus altissima (Mill.) Swingle	58,461,747	6.7
Quercus rubra L.	88,914,371	10.2
Prunus serotina Ehrh.	124,984,909	14.3
Robinia pseudacacia L.	1,808,001,266	206.4
Other species	86,283,872,360	9,850.7

be carried out at plot level to study the effects of site features and management practices.

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